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Defects Reduction in a Pump Manufacturing Industry Using Six Sigma Methodologies

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Abstract:- Six Sigma is used for produce high-quality products with the low cost. This research defines a step-by-step guide, using the DMAIC (Define, Measure, Analyse, Improve, and Control) methodology. Also the effectiveness of the DMAIC has been calculated with a case study carried out in a south Indian industry. This methodology is mainly used to recognize the hidden waste and costs, identify and eliminate defects, increase profit margins, increase the employee's level of commitment and fulfillment, on time delivery and in turn to improve customer satisfaction. In this research, the prime focus is on improving customer satisfaction in the pump manufacturing industry. This study mainly used on employee job fulfillment and executing Six Sigma is also studied. It shows that members of Six Sigma have experienced positive changes in most job fulfillment measures. Implications of the evaluation investigated with direction for further action of the company.

In pump manufacturing industry, during manufacturing of submersible pump ovality occurs in pump sleeve. The manufacturing process of pump sleeve consists of following process, metal cutting, rolling, tig welding, plunging, ring welding, slotting and buffing.

Here ovality problem occurs during the welding followed by plunging operation. To neglect this ovality problem, instead of welding followed by plunging operation deep drawing operation is suggested.

Keywords:- *Pump Sleeve,Six Sigma System, Welding Operation.*

I. INTRODUCTION

Implementation of Six Sigma in the pump manufacturing industry to increase the customer satisfaction includes product quality and timely delivery of the product. Pump sleeve manufacturing process, in general, various parameters involved for affecting the various forming quality features of the product. Some of the parameters are controllable while some are uncontrollable. Generally, the procedures of pump manufacturing process are the same even though the materials used in the processes are different. A large number of experimental investigations for the effect of pump sleeve manufacturing process with quality have been carried out by the researchers and industry engineers over the past few decades.

The purpose of the process development is to increase the performance characteristics of the process based on customer needs and expectations. By using experimentation it can be reached and the aim is to reduce and control variation of a process. Subsequently, decisions must be made concerning which parameter affects the performance of the process. The loss function quantifies the design factor which influences the average and variation of performance of the process. By properly adjusting the factors, the variations of the process are reduced thereby the losses can be minimized. The statistical theory of experimental design is mainly used for new statistical tools and concepts for improving the quality.

The human side of Six Sigma implementation is an important area because it contributes to the science and practice of the implementation to reduce the waste and create value. The empirical study of job satisfaction upon implementing Six Sigma determines the satisfaction level of employee's commitment. The company is mainly focused for changing its functions and improving its processes; employees willingly go along and give their best effort. The customers are increasingly emphasizing flawless delivery, that is, very short cycle, on-time delivery, and responsiveness to the customer's changing needs. In today's highly competitive business environment, only innovative product manufacturers can provide customized and innovative products and in the process, they also achieve innovative performance dimensions.

The present study aims at implementing the DMAIC based Six Sigma approach in order to reduce the incidence of defects to achieve product quality, increase the sigma level of the sand casting process, on-time delivery and customer satisfaction at the least cost. Job satisfaction, base stock level

inventory system and overall equipment efficiency are also determined and analyzed.

II. EXPERIMENTAL PROCEDURE AND TECHNIQUES

Earlier investigations have made either inadequate or no attempt to study the implementation of Six Sigma in the manufacturing company to improve customer satisfaction. The present investigation has been undertaken with the aim of studying a relationship between the process parameters to reduce the defects in forming operations, the employee's commitment and job satisfaction level on implementing Six Sigma methodology and the on-time delivery of the products. Further, the optimized results are validated by an innovative optimization technique. The new inventory base stock model for optimal stock to meet on- time delivery have been tested and incorporated in the Six Sigma study. Finally, the effectiveness of the approach is subsequently evaluated and the organization benefits received through this new approach by measuring OEE in the Six Sigma environment are analyzed in the implementation model.

III. FLOW DIAGRAM OF DMAIC METHODOLOGY

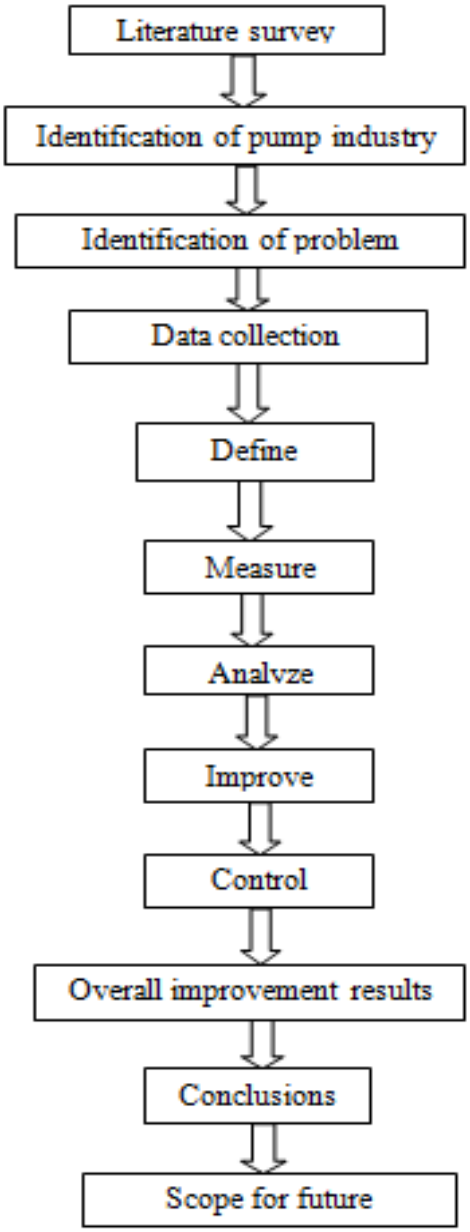


Table 5.1 SIPOC Diagram (Supplier-Inputs-Process-Output-Customers)

Suppliers List the suppliers of any inputs to this process	Inputs List the inputs of any inputs to this process	Process Describe the process and list the key process steps	Outputs List the outputs of any inputs to this process	Customers Identify the customers of this process outputs	Suppliers List the suppliers of any inputs to this process
Raw material- SS coil of 0.8×270 Grade 202	Man power-10 members	Start \/\/ SS sheet Shearing and slotting \/\/ Rolling the sheared sheet metal \/\/ Welding & pressing \/\/ Plunging the welded sheet \/\/ Buffing the finished sleeve \/\/ Outer ring welding & forming \/\/ Inner ring welding \/\/ Dispatching	Output- Submersible pump sleeve for besten pumps India pvt. Ltd.,	Customer- Besten pumps India pvt. Ltd.,	
Source- Besten pumps India pvt. Ltd.,	Equipment – shearing machine Slotting machine Rolling machine TIG welding machine Plunging machine Power press Buffing machine				
Manufacturers-Real ships Bangalore					
Suppliers- Real ships					

IV. ENHANCING JOB SATISFACTION

The company endured a lot of problems in controlling the sleeve manufacturing process without deviation as prescribed in the designed level.

Generally, most of the irregularities are caused by the workers who did not cooperate in adopting new technology or any philosophies due to their dissatisfaction on job. Hence, before implementing the new methodology, the existing environment is tested to identify the satisfied level of the workers. Primary data, regarding various factors that influenced the job satisfaction of company employee like comfort, influence, cooperation, fellowship, personal development, employee designation, working conditions, salary, recognition in job, self-satisfaction in job, level of motivation etc.

Data for this investigation are collected in two steps, starting with seeking permission from the authorities concerned. Prior appointments are obtained from the technical workers who are given the questionnaire personally and requested to complete the schedules at their own time and leisure.

V. EMPIRICAL STUDY ON EMPLOYEE JOB SATISFACTION UPON IMPLEMENTING SIX SIGMA DMAIC METHODOLOGY

Forming is the most widely used process to produce pump sleeve among the sleeve manufacturing processes. Several types of defects could occur during forming and considerably reduce the total output of pump sleeve, besides increasing the cost of their production. Whenever a defect occurs in forming, the various departments in the industry normally blame each other for its occurrence. correct identification and finding the root causes for the defect is difficult due to the involvement of various technical factors like process design, process flow and as well as human factors. Forming defects may be defined as those characteristics that create a deficiency or imperfection, contrary to the quality specifications imposed by the design and the service requirements.

- *Measure Phase*

Engaging the process by which the team is formed, its mission is described, its resources allocated, its goals set, its membership is committed and its plans are made. After intense brain storming, several defects are identified and measured. The surface defects are identified by the visual inspection. The most significant defects considered in the current research are ovality in pump sleeve, flatness incurrence.

Table 5.2 DEFECTS DATA

Sl. No	Defects	No. of Defective Pump sleeve		
		Feb	Mar	Period of study(2 weeks)
1	Ovality	456	516	207
2	Surface	129	198	135
Total production		8085	9067	4155
Total rejection		585	714	342
Rejection %		7.23	7.88	8.23

Table 5.3 PROJECT CHARTER

Product or service impacted	Besten pumps india pvt ltd	Looking for expect savings	
Black belt or green belt	Improvement group	Business unit	Manufacturing unit
Start date		Expect Target completion date	
Element	Description	Team charter	
Process	The process in which opportunity exists.	Pump manufacturing industry	
Project description	Problem and goal statement (project's purpose)	Problem statement: The customer complaints had increased in the past one year and if not focused may lead to high internal rejection and customer dissatisfaction. Goal statement: To reduce ovality in the pump sleeve and attaining flatness.	

Objective:	Measurable objectives to implement DMAIC to improve customer satisfaction Pilot DMAIC study enhancing job satisfaction	Project parameters	Baseline (Existed)	Goal3 (Arrived)	Entitlement (6 Sigma)	Units
Measurable Objectives to implement DMAIC to improve customer satisfaction level of employee optimization of process parameters	Application of DOE	Sigma level	3.22	3.47	Improved	σ Level
		Satisfaction level	---	High		σ Level
		Sigma level	3.47	3.68	Improved	σ Level
optimization of process parameters		Sigma level	3.68	3.8	Improved	σ level
Optimization of inventory system	Application of Base stock level	On-time delivery performance	Deterministic Demand	Stochastic Demand	Satisfied Level	Days

Evaluate the results of six sigma system	Application of OEE	Equipment Effectiveness				σ Level

Business Cases:	Expected financial improvement, or other justification	The project is worth doing to increase the customer satisfaction, decrease defects, and increase profit. Initially, the rejection value of this product is 8.32% and operating at 3.32 levels. The project covers a wide range of processes and improvement anywhere. Increase in Sigma level of this process will lead to increase in productivity, customer satisfaction and business improvement.
Team members:	Santosh.R Sendhil kumar.S Sethupathi.P Sivanesan.S	The Development Group consisted of two Operators.
Scope:	Which part of the process will be Investigated and excluded.	The entire process includes production, job satisfaction, equipment efficiency and on-time delivery of the products Should be analyzed and depending upon the defects and problems, it is prioritized.
Benefit to External Customers	Identify the final customers, what are their key measures, and what benefits will they see?	On-time delivery of defect less products to satisfy the customer in the stochastic environment.

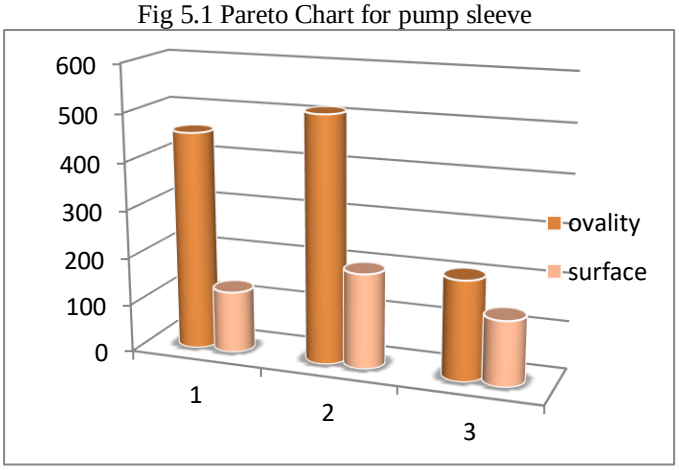
Schedule: Dates Representing The real study is started and stopped. It is given by the improvement group after scrutinizing the research word carried our separately according to the problems. pilot study also included in the calculated schedule	Give the key Milestones/dates. M- Measurement A- Analysis I- Improvement C- Control Note: Schedule appropriate Safety Reviews	Project Start	10-02-2016
		"M" Completion	26-02-2016
		"A" Completion	18-02-2016
		"I" Completion	20-02-2016
		"C" Completion	22-04-2016

		Safety Reviews	25-03-2016
		Project Completion	27-03-2016

➢ *Analyze Phase*

Variation sources are identified through analysis of historical data. With the help of historical and Pareto chart, factors that influenced the rejection most are identified. Ovality accounted for higher percentage of rejection value due to welding followed by plunging operation. More rejections are due to plunging operation. The total defect rejection percentage during the period is 8.23. At this stage of Six Sigma implementation, the goal is to substantiate a valid relationship between the manufacturing defects and their influencing factors, and thus to identify the critical input variables which have a significant contribution to the response functions.

Fig 5.1 Pareto Chart for pump sleeve



➢ *Improve Phase*

The main purpose of this stage is to improve the performance in manufacturing process. The root cause of the problem is identified and the team is activated to generate ideas for resolving the technical and operator unawareness problem by offering important corrections to improve the performance.

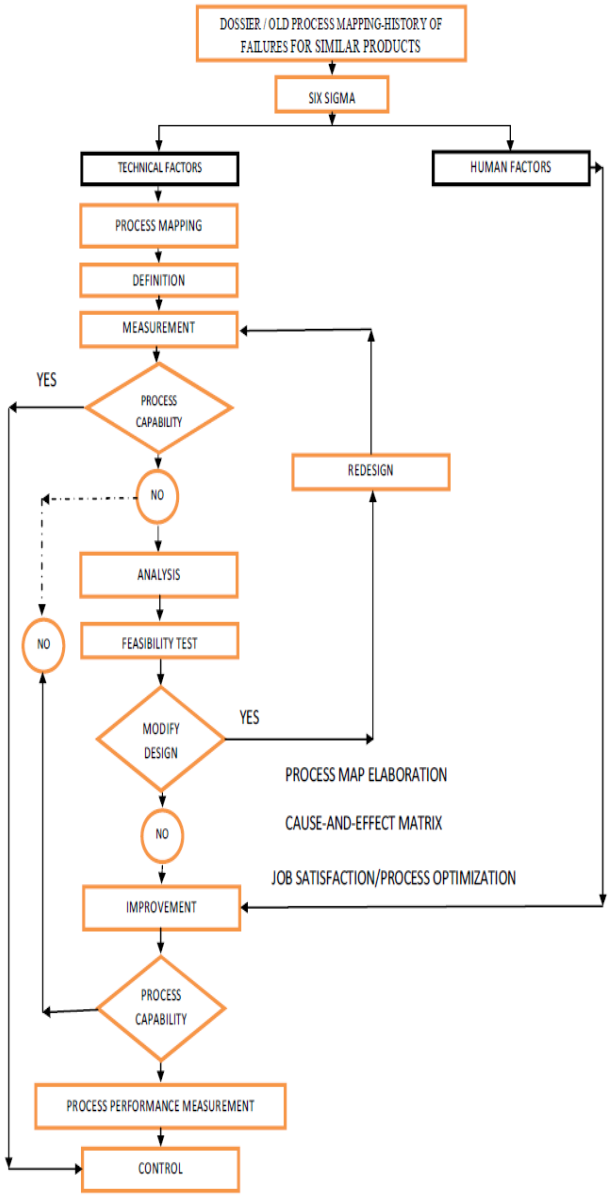


Fig 5.2 Flow Chart for Improve Phase

➢ *Control Phase*

The process performances and documentation maintained and updated with information by using continuously monitoring.

Sigma level is calculated to assure that the Six Sigma spread of the process comfortably fits into the improvement level.

In the check phase, pilot study of the process overall rejection quantity decreased from 342 pump sleeve to 149 pump sleeve. The rejection percentage decreased from 8.23 to 3.73. At the same time, additional care is taken and corrective action is taken in the next cycle or revised approach to meet Six Sigma level and yield the desired results.

➢ *Defects data - Pilot DMAIC study*

Table 5.4 Defects data - Pilot DMAIC study

Month	Defects Types	No of defective	Percentage Of defective
	Ovality	92	2.3
	surface	57	1.42
	Total production	3987	
	Total reduction	149	
	Rejection %		3.73

VI. RESULT

The problem (pump sleeve defects) faced in the company are discussed and reason for the problem also given in the different phases. The quality and surface in flatness are responsible for 60.60 and 39.47% of defects in the total production. The Sigma Value of the company is 3.32 and the process capability is 1.11. Pareto, cause and effect tools are used to analyses the causes for the pump sleeve defects in the analyses phase. The technical corrections is given in the improve phase to reduce the pump sleeve defects. In the control phase, after the application of DMAIC in the pilot study the casting rejection percentage decreased from 8.23 to 3.73 is given.

VII. CONCLUSION

In pump manufacturing industry the problem identified in pump sleeve is ovality and flatness which occurs during plunging and welding operation. To neglect this problem deep drawing operation is suggested instead of plunging followed by welding. Deep drawing operation can reduce the pump sleeve defects using six sigma methodologies. The percentage of sleeve being reduced to 54.67%.

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